APPENDIX G
A METHOD FOR DETERMINING IF A WATER BEARING UNIT SHOULD BE CONSIDERED AN AQUIFER

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Several criteria must be met for a water-bearing zone to be considered a potentially usable aquifer. First, the water quality must be such that consuming the water does not pose an immediate or long-term risk to human health. Second, the water-bearing materials must yield at least enough water to serve a useful purpose. Realistically, if the water-bearing materials cannot adequately supply a single household, then it is doubtful if they would be considered an aquifer. Two factors controlling the volume of groundwater that can be produced from water-bearing materials are the hydraulic conductivity and the saturated thickness of the potential aquifer. It is necessary for both of these factors to be considered. The greater the hydraulic conductivity of the water-bearing materials, the greater the yield potential. However, a thick sequence of low hydraulic conductivity materials may actually yield more water than a thinner unit having a much higher hydraulic conductivity.

The technique described below was developed to aid in determining if a water-bearing unit should be considered an aquifer. A series of calculations were made based on several assumptions. It was assumed that to be considered a viable water supply, a well would need to be able to produce a minimum of 0.25 gallons of water per minute (360 gallons per day) for a period of 10 days. The calculated drawdown at the well at the end of this period could not exceed one-third of the saturated thickness of the water-bearing unit. A storage coefficient of 0.001 was assumed. The well was assumed to have an efficiency of 100 percent. The Theis nonequilibrium well equation (a.k.a., nonleaky artesian formula) was used to calculate the aquifer transmissivity necessary to meet these parameters for aquifer thickness between 10 to 200 feet. Hydraulic conductivity values were determined by dividing the calculated transmissivity values by the full saturated thickness.

The calculated hydraulic conductivity values were plotted against the saturated thickness of the aquifer (see graph on page G-4). The data plotted as a power function. A curve-fitting program was applied to derive the following empirical equation:

$$K = b^{-2.04} \times 1447 \qquad (1)$$

where,

K = hydraulic conductivity (gpd/ft^2), and
b = aquifer saturated thickness (feet).

If the saturated thickness of the water-bearing zone under consideration is known, then the equation can be used to calculate the average hydraulic conductivity that will be necessary to meet the minimum aquifer requirements listed above. Conversely, if a representative value for the hydraulic conductivity has been determined, then the equation can be re-written to determine the minimum saturated thickness that will be needed to meet the minimum aquifer requirements shown above. That equation is:

$$b = K^{-0.496} \times 35.33 \tag{2}$$

Hydraulic conductivity values in units of gpd/ft^2 and ft/day are commonly used in the water supply field but are not widely used in environmental work where hydraulic conductivity values are typically reported in units of cm/sec. To convert a hydraulic conductivity value measured in gpd/ft^2 to cm/sec, multiply it by 7.75×10^{-5}.

Below are two examples:

EXAMPLE 1

Test drilling and slug tests show that a water-saturated sandy silt has a hydraulic conductivity of 2.5×10^{-4} cm/sec. A thick clay unit underlies the materials, and the saturated thickness of the sandy silt unit is 23 feet. Does it meet the criteria necessary to be considered a potentially usable aquifer?

We will assume the water quality meets minimum requirements for potability. A hydraulic conductivity of 2.5×10^{-4} cm/sec is equal to 3.2 gpd/ft. With this hydraulic conductivity, the minimum saturated thickness needed is from Equation (2):

$$3.2^{-0.496} \times 35.33 \text{ or } 19.8 \text{ feet}$$

Based on the above, the zone would be considered a potentially usable aquifer.

EXAMPLE 2

Test drilling below a site shows 80 feet of fairly uniform sandy clay till. What would be the minimum average hydraulic conductivity necessary for this material to comprise an aquifer?

$K = 80^{-2.04} \times 1447$
$K = 0.19$ gpd/ft^2 or 1.47×10^{-5} cm/sec

Based on this technique, 80 feet of sandy clay till having an average hydraulic conductivity of 1.47×10^{-5} cm/sec (or 0.19 gpd/ft^2) would be considered a usable aquifer.

Changing any of the aquifer parameters and yield assumptions listed above would, of course, change equations 1 and 2 above. Some argument could be made as to the assumed pumping period of 10 days. Perhaps a pumping period of 1 day might seem more appropriate. However, it must be remembered that the Theis nonequilibrium equation assumes confined (artesian) conditions. For it to be entirely valid, the saturated thickness of the aquifer must remain essentially unchanged. The drawdown must not lower the potentiometric surface an appreciable distance below the top of the aquifer. Most shallow aquifers that will be considered under this rule will likely be unconfined. As drawdown occurs in an unconfined aquifer, the saturated thickness of the aquifer within the drawdown cone decreases. Thus, the transmissivity (which is the product of the hydraulic conductivity and the saturated thickness) also decreases. Reducing the saturated thickness of an unconfined aquifer by one-third will reduce its transmissivity proportionally. Because of this, the assumed drawdown of one-third the aquifer thickness is probably optimistic for an unconfined aquifer. The actual drawdown will be somewhat larger if the well is actually pumped 0.25 gpm for 10 days. If a shorter pumping period is selected for consideration, then the allowable drawdown should be changed from one-third the saturated thickness of the aquifer to a more conservative value, such as 10 percent of the saturated thickness of the aquifer.